CHARACTERIZATION OF IMPACT EJECTA DEPOSITS FROM METEOR CRATER, ARIZONA. T. A. Gaither[1], J. J. Hagerty[1], J. F. McHone[1], and H. E. Newsom[2], [1]U.S. Geological Survey, Astrogeology Science Center, 2255 N. Gemini Dr., Flagstaff, AZ 86001 (tgaither@usgs.gov), [2]University of New Mexico, Institute of Meteoritics, Albuquerque, NM

Introduction: Previous studies of impact melts from Meteor Crater [1-3] have reported a large range of compositions, including chemically fractionated projectile-derived Fe-Ni metal alloys and sulfides, and variable olivine, pyroxene, and melt compositions. We are in the process of augmenting results from past studies with new data derived from ejecta blanket drill cuttings in an effort to map the spatial distributions of meteoritic components and impact melts. Herein, we present initial results of our investigation of the physical distribution patterns and chemical composition of impact melts, metallic spherules, and meteoritic fragments from Meteor Crater, AZ. The research used the USGS Meteor Crater sample collection of rotary drill samples from the ejecta blanket. This collection, which encompasses the entire extent of the ejecta blanket, is an invaluable resource for determining the geologic character of impact generated lithologies. These samples can be accessed and requested by visiting the following website http://astrogeology.usgs.gov/research/Meteor-Crater-Sample-Collection.

Methods: To assess the distribution patterns of Meteor Crater impact melts, we estimated modal percent impact melt versus target rock matrix within drill hole samples along four primary transects identified by Roddy et al. [4]. Magnetic impact melts and meteoritic fragments were removed with a hand magnet, and non-magnetic melt objects were removed using a binocular microscope and picking tweezers. Representative fragments were mounted in 1-inch epoxy rounds and were analyzed with the scanning electron microscope (SEM) at the Department of Geology of Northern Arizona University. We used backscattered electron (BSE) imaging and Energy Dispersive Spectroscopy (EDS) to evaluate and document the various types of impact melt fragments. Impact melt glasses and metallic spherules were also analyzed by electron microprobe for major and minor element concentrations. Analyses were conducted on the JEOL JXA 8200 electron microprobe at UNM's Department of Earth and Planetary Sciences using 15 kV, 20 nA, and a 1 µm spot size.

Results: Our assessment of the lateral and vertical distribution patterns of meteoritic materials within the ejecta blanket reveals that, in the NE, SW, and SE transects, impact melts are concentrated within a zone ~270-300 m from the crater rim, at depths of 2-4 m. We find that impact melts are rare nearer to the rim and further out than ~300 m. Only trace amounts (<2%) of impact melts are present at depths of 0-2 m and deeper than ~4 m, although intact melt clasts are found as deep as 10.5 m. Interestingly, samples from drill holes in the NW transect contain only trace amounts of meteoritic material.

Impact melts are typically 1-3 mm in diameter (though many are 1 cm or larger), round, oblong, or teardrop shaped and are often coated with white/tan carbonate and quartz rinds. The fragments have black or brown exteriors, highly vesicular interiors of red-orange glass, and contain mineral and lithic inclusions. The majority of impact melts discussed here are generally similar to those described by [1], with some important differences (see discussion below).

Discussion: Our systematic examination of impact melt distribution indicates that the zone of greatest impact melt abundance (2-4 m deep) is dominated by Kaibab ejecta, with variable contributions from the Coconino and Moenkopi Formations. We suggest that this zone of high impact melt concentration is an original feature of the ejecta blanket, while the melt fragments in the upper 2 m were subjected to alluvial and/or colluvial processes.

Impact melt fragments are compositionally heterogeneous and have a groundmass consistent with a mafic glass (i.e., SiO_2, MgO, FeO, CaO). Compositional variation between and within melt clasts is similar to that described by Hörz et al. [1]. For instance, the mafic groundmass has two variations: a homogenous Fe-rich glass from which pyroxene needles grew, and a Mg- and Ca-rich glass from which dendritic pyroxene crystals grew. The majority of the melt fragments contain angular, fractured quartz grains, which frequently display apparent disequilibrium textures (i.e., partially resorbed grain boundaries) as well as metallic spherules.

Additionally, we observe carbonate lithic inclusions in several melt fragments, in contrast to the near-absence of carbonate inclusions noted in other studies [i.e., 1-5]. We also detect abundant lechatelierite clasts within the drill cuttings, with large (5x3x2 cm) pieces occurring as deep as 7 m. Furthermore, we identify inclusions of lechatelierite within impact melts, which provide clues to the sequence of formation for these materials.

We discovered a unique suite of highly metallic impact melt fragments (Fig. 1) which were initially assumed to be meteorite fragments based on their highly magnetic character and deeply oxidized exteriors. However, SEM analyses showed that these fragments have unique textures and compositions relative to Canyon Diablo fragments [6] and the above described impact melts. These non-vesicular fragments have a Fe-rich (>90 wt%), compositionally banded groundmass, with varying proportions of Fe, Ni, and Si. These fragments also contain angular, shattered quartz grains as well as Ca- and Mg-rich lithic inclusions.

A unique lithology is evident in the first few feet of almost all drill holes at Meteor Crater: small magnetic clasts which are black or brown, minimally to moderately vesicular, irregularly shaped, and <1 mm to 2 mm in diameter. These fragments contain an Al-rich (i.e., 8–15 wt% Al_2O_3), but still mafic, groundmass relative to the impact melts. Their mineralogy is dominated by plagioclase grains with consistent An_{79} composition. Many of the fragments have weakly zoned olivine phenocrysts and several oxide phases, including chromite. These fragments do not contain any shattered quartz grains or metallic spherules. This information, in conjunction with their surficial occurrence in the ejecta blanket (i.e., 0-1 ft), suggests that these fragments are not impact melts and may instead be volcanic clasts derived from the nearby San Francisco Volcanic Field.

Conclusions: The drill cuttings from the Meteor Crater ejecta blanket are providing new data that confirm the results of previous studies while also providing exciting new information. Our preliminary results have allowed us to make the following conclusions:

- The compositions and textures observed within the new type of impact melt indicate that mixing processes were more complex than previously thought.
- Lechatelierite is common, if not pervasive, within deeper portions of the ejecta blanket. Quantification of the volume of lechatelierite within the drill hole samples may lead to an upward revision of the volume of Coconino Sandstone-derived impact melt ejected from the transient crater.
- Inclusions of lechatelierite within impact melt clasts indicate that shock-melted Coconino Sandstone may have had a greater role in mixing processes that occurred during melt formation than suggested previously by [1].
- Inclusions of dolomite and calcite within several melt clasts suggest that the carbonate-rich Kaibab target rock was not completely volatilized after melting, supporting the interpretations of [5].

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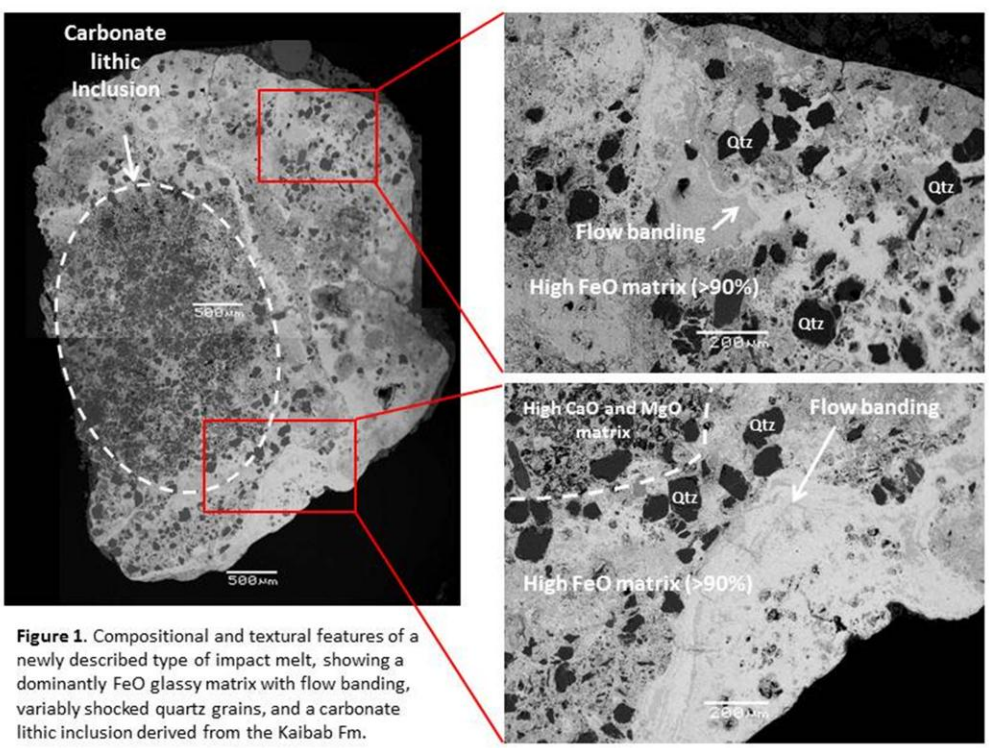

Figure 1. Compositional and textural features of a newly described type of impact melt, showing a dominantly FeO glassy matrix with flow banding, variably shocked quartz grains, and a carbonate lithic inclusion derived from the Kaibab Fm.